

## THE CLAIMS

What is claimed is:

1. A method for characterizing a dose of implanted atomic species in a substrate, which comprises:

annealing the substrate after implantation of the atomic species, with the anneal conducted at a temperature and for a time sufficient to cause the implanted atomic species to form blisters in a surface region of the substrate but below that which would cause a number of the blisters to burst;

imaging the surface region of the substrate to obtain a surface image; and

processing the surface image to determine the characteristics of the implanted dose of the atomic species.

2. The method of claim 1, wherein the characteristics of the implanted dose of the atomic species are quantitative characteristics.

3. The method of claim 2, wherein the surface image is observed to determine density or size of the blisters, or both density and size.

4. The method of claim 2, wherein the surface image is obtained by a charge coupled device and the implant dose is characterized by a density parameter.

5. The method of claim 2, wherein the surface image is observed to determine blister area.

6. The method of claim 1, wherein the blister density is calibrated as a function of implantation dose prior to annealing.

7. The method of claim 6, which further comprises calculating the implantation dose of atomic species by comparing the processed surface image to images of known implanted doses of atomic species.

8. The method of claim 1, which further comprises establishing compensation factors for implantation dose measurements by comparison of the processed image to reference implantation data.

9. The method of claim 8, wherein a compensation factor is applied to an implanter to obtain improvements in subsequent implanted doses.

10. The method of claim 8, wherein a compensation factor is determined by balancing implantation operations performed by different implanters that are used to implant the atomic species.

11. The method of claim 1, wherein the characteristics of the implanted dose of the atomic species are qualitative characteristics.

12. The method of claim 1, which further comprises analyzing spatial distribution of the blisters from the processed image to determine uniformity of implantation of the atomic species.

13. The method of claim 1, which further comprises performing blister measurements on different locations of the substrate surface so as to obtain a spatial distribution of the dose over the surface of the substrate.

14. The method of claim 1, which further comprises performing blister measurements on a plurality of substrates which have been annealed under the same conditions but with different orientations in order to determine local temperature effects.

15. The method of claim 1, wherein the processed image is observed to characterize the uniformity or thickness of the implanted dose of atomic species.

16. The method of claim 14, wherein the uniformity is determined by establishing regions of the substrate that have received a dose of atomic species per unit area that differ from a mean dose of atomic species that is received by the substrate.

17. The method of claim 1, wherein the atomic species that is implanted comprises hydrogen or helium and the implantation is conducted at a dose of greater than  $10^{16}$  atoms per square centimeter.

18. The method of claim 1, wherein the annealing is conducted for a time of between about 5 and 20 minutes at a temperature of between 300 and 550°C.

19. The method of claim 1, wherein the substrate comprises a semiconductor material.

20. The method of claim 19, wherein the semiconductor material is a silicon single crystal.